Microclimate Investigations on Permeable NBC Protective Garments

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1. Introduction

According to the **operational requirements of NATO**, NBC Protective Clothing Systems must be suitable for extended periods of wear in all climatic environments without creating unacceptable heat stress and serious reduction of the protective capability.

The demand for balancing wear comfort and protection confronts the developers with a challenging task. The physiological wearing properties of NBC Protective Garments can be improved for example, by reducing the activated carbon loaded filter layer in weight and thickness, or by increasing the air permeability. In most cases however, this results in the loss of protective capacity. By employing filter layers using activated carbon with hydrophilic properties, this disadvantage is avoided.

The properties of fabrics and ensembles which are most relevant to the physiological effects on the wearer are water-vapour and thermal resistance.

In addition, the **microclimate** plays an important role. It is influenced by the above-mentioned parameters and the trapped air between the clothing layers and underneath the clothing, which is determined by the flexibility of the fabrics as well as cut, pattern and fit of the garments.

The microclimate is particularly influenced by the ability of the textile layers for short-time water-vapour uptake and their moisture-buffering capacities: a good uptake and buffering of interstationary sweat pulses in the area close to the skin has the following effects:

- low increase in humidity immediately after the occurrence of the sweat pulses,
- small peak value of humidity, and
- fast decrease of humidity in the microclimate.

Since temperature also decreases together with humidity, the positive effects on the subjective wearing comfort are considerable.

2. Methods and results

Please refer to the following 4 figures.

Paper presented at the RTO HFM Symposium on "Blowing Hot and Cold: Protecting Against Climatic Extremes", held in Dresden, Germany, 8-10 October 2001, and published in RTO-MP-076.

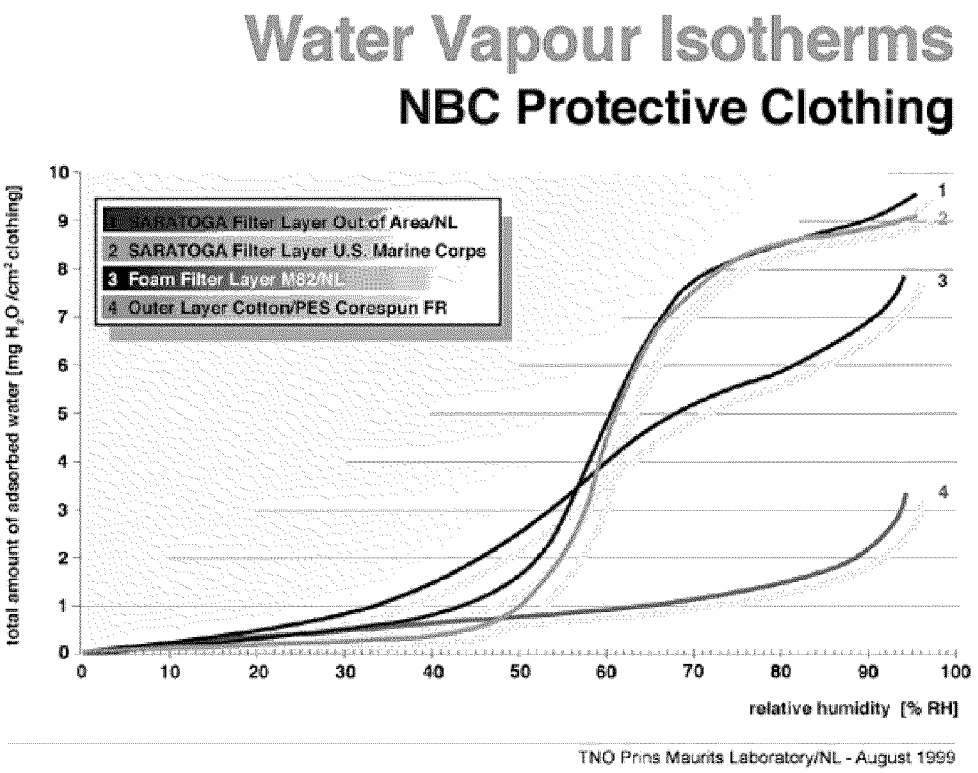

Figure 1: Calorimetric Test Method - Thermochimica Acta No. 34 (1979 page 109)

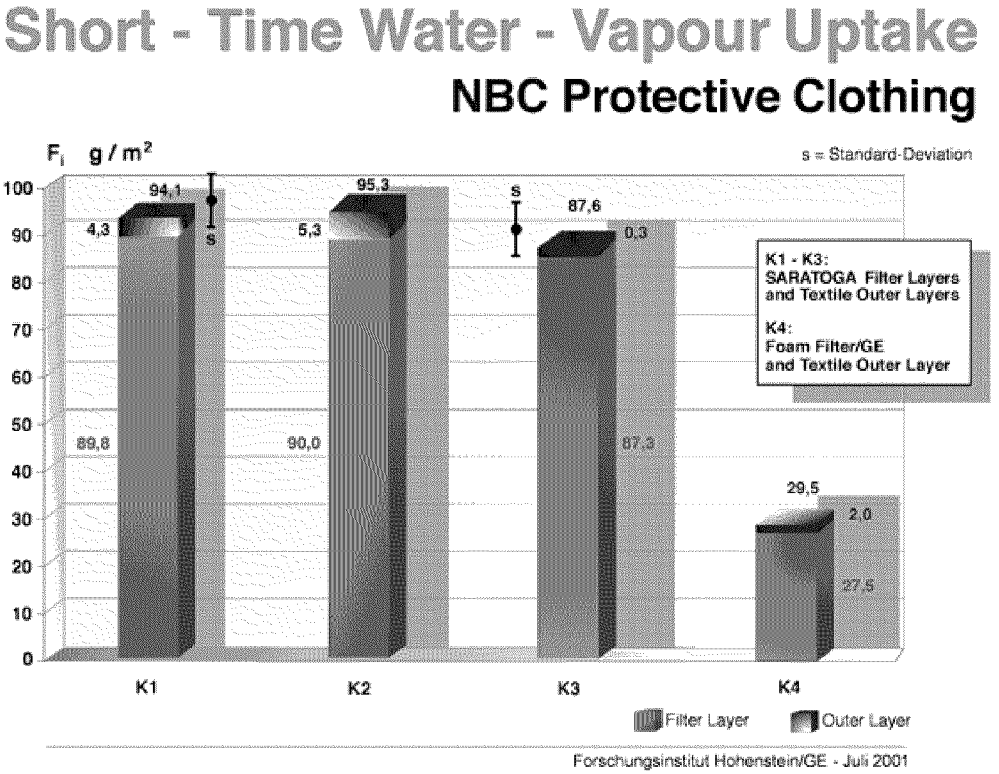

Figure 2: Skin Model Measurement - DIN EN 31092 (02/94) / ISO 11092 (10/93)

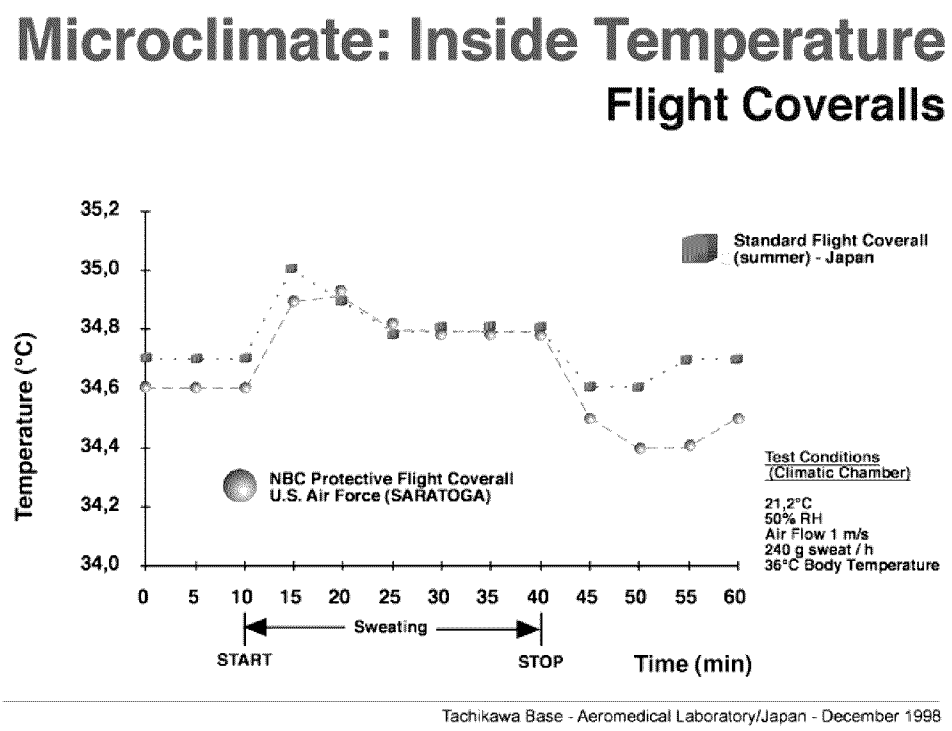

Figure 3: Climatic Chamber Test using TOM-III sweating mannequin of TOYOBO

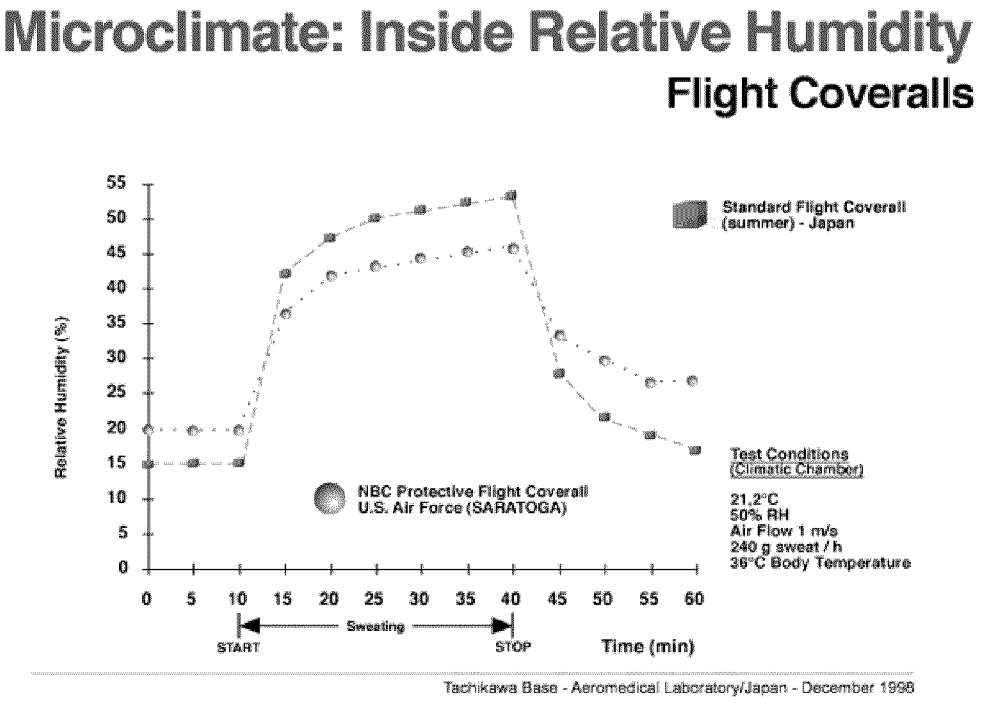

Figure 4: Climatic Chamber Test using TOM-III sweating mannequin of TOYOBO

3. Discussion

The ability for **short-time water-vapour uptake** of filter layers on the basis of activated carbon in the form of spherical adsorbents (SARATOGA™), compared to foam filter layers is very high. The main reason for this are the **hydrophilic properties** of the spherical adsorbents. Another reason is the **free accessibility of the adsorbents** for water-vapour molecules. Whereas the particles of the activated carbon powder used in foam filter layers are covered by a layer of adhesive, the outer surface and thus also the pore system of the spherical adsorbents are accessible without hindrance.

The **water-vapour buffering capacity** of filter layers on the basis of spherical adsorbents is also very high. The moisture regulation index of 0,40 to 0,42, established by the Forschungsinstitut Hohenstein / Germany (Interstationary Skin Model Measurement - Hohenstein Standard Test Specification BPI 1.2.) corresponds to that of working clothes and can be described as being good regarding its wear comfort.

As the water-vapour molecules in the spherical adsorbents are bound only very lightly, the moisture is easily desorbed and transported to the outside due to the existing pressure gradient.

The results of climatic chamber tests conducted in Japan using a "sweating mannequin", very clearly demonstrate the influence of filter layers with spherical adsorbents on a pleasant microclimate.
The established values for **inside relative humidity and inside temperature** are better for the SARATOGA™ Flight Coverall of the U.S. Air Force than for the light and fluffy summer Flight Coverall of the Japanese Air Self-Defence Force, which does not have an activated carbon layer.

Moisture in the spherical adsorbents has no remarkable influence on the protective capacity. Molecules of skin damaging and skin penetrating chemical warfare agents, due to their considerable higher heat of adsorption, very quickly displace the water-vapour molecules.

4. Conclusion

NBC Protective Garments on the basis of the spherical adsorbents technology (SARATOGA™) offer the best possible wearing comfort, in particular under hot and humid climatic conditions, without impairing chemical protection.
This has been proven practically in several field trials conducted over the past few years (U.S. Marine Corps, Joint Service Lightweight Integrated Suit Technology Program of the U.S. Forces, German Army and Air Force, Hungarian and Dutch Army).